Original Research Article

"EFFECT OF NANO FERTILIZER ON GROWTH, YIELD AND QUALITY OF OKRA *(Abelmoschus esculentus*)"

ABSTRACT

The present investigation was conducted to study the effect of nano fertilizer in the growth yield and quality of okra *(Abelmoschus esculenthus*). The experiment was carried out at the instructional farm of ICAR- Krishi Vigyan Kerndra, Pathanamthitta, Kerala, during the year 2021. The experiment was laid out in randomized block design with three replications. Ten different treatments were carried out with different combinations of fertilizers. The result obtained with treatment T2 (Soil application of 50% RDF as Traditional fertilizer + 50 % recommended dose of nano N as foliar application , P&K as soil application) was recorded the best among in all combination of Traditional fertilizer NPK and nano NPK in term of growth, yield attribute and quality parameters like Plant height (120.21 cm), Number of leaves per plant (83.99), Number of branches per plant (3.62), Days to first harvesting (46.97), Pod length (12.72cm), Pod width (1.65cm), Number of pods per plant (29.23), Average of pod weight (12.67g), Pod yield per plant (370.39g), Pod yield per plot (8.89kg), Pod yield (131.69q ha-1) and TSS (2.930Brix). The highest cost benefit ratio (3.59) was also observed in T2 (Soil application of 50% RDF as Traditional fertilizer + 50 % recommended dose of nano N as foliar application ,P&K as soil application).

INTRODUCTION

Okra (*Abelmoschus esculentus*) belongs to the family Malavaceae. It is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on large commercial farms. It is grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Malaysia, Brazil, Ghana, Ethiopia, Cyprus and the Southern United States [1]. India is the largest producer of okra with a production of 6355 tonnes in 521 thousand hectors [2]. Okra plays an important role in the diet by supplying carbohydrate, protein, fat, minerals and vitamins that are usually deficient in the staple food. It is basically low in calories and dry matter constituents which when consumed in a meal with basic starchy food makes the food more palatable. Every 100 g green pods of okra contain protein 1.8g, carbohydrate 6.4 g, fibre 1.2 g, vitamin C 18 mg and calcium 90 mg [3]. The immature pods are used as vegetable and its dried form is often used as soup thickener [4].

Unscientific application of conventional fertilizers by the farmers for increasing the crop productivity, although their excessive use is causing problems like environmental pollution, water contamination, toxicity in food items so posing a health hazard for human beings and

animals. The nanotechnology is playing an imperative part in the productivity with control on nutrients release, target specific, smart delivery system and monitoring irrigation water quality for sustainable development of agriculture [5]. Nanotechnology refers to the application of molecules and compounds whose size does not exceed 100 nm. This technique depends on reducing the particle to a size equal to one billionth of a meter (10^{-9} m) and then using the new material.[6] The nano fertilizer allows incorporating nutrients onto a nano dimensional adsorbent. Therefore, this approach leads to the controlled release of active ingredients for a long time and prevents the leaching of nutrients into groundwater, thus reducing the amount of fertilizer used. It is estimated that the amount of nano formulations needed for plants is only equivalent to 20% of conventional fertilizers [7]. Nanotechnology is a new perspective of precision farming which maximizes the output from crops while minimizing the inputs such as fertilizers, pesticides, fungicides and herbicides. Vegetables are voracious nutrient mining crops having a very huge requirement of nitrogen and phosphorus so development of nano form of these will be suitable for the different vegetable crops to enhance the nutritional quality [8]. However, works done on nano-fertilizers is very limited across the global but the reported literature clearly demonstrated that these customized fertilizers have a potential role to play in sustaining farm productivity. Therefore, the aim of this work was to study about the effect of nano fertilizers on the of growth, yield and quality parameters of Okra (*Abelmoschus esculentus*).

MATERIAL AND METHODS:

The experiment was carried out at the ICAR-Krishi Vigyan Kendra, CARD, Pathanamthitta District, Kerala, India, during the year 2021.

The variety Arka Anamika was used for carrying out the experiment. The experiment was laid out with Randomized Block Design and replicated three times. Okra was planted in the field at a spacing of 0.45 x 0.60 m in plot of 2.25 x 3 m size. There were ten treatments as follows T1 [Soil application of 75% RDF as Traditional fertilizer + 25 % recommended dose of nano N as foliar application, nano P&K as soil application)], T2 [Soil application of 50% RDF as Traditional fertilizer + 50 % RDF of nano N as foliar application, P&K as soil application], T3 [Soil application of 25% RDF as Traditional fertilizer + 75 % recommended dose of nano N as foliar application, P&K as soil application], T4 [Soil application of 75% RDF as Traditional fertilizer + 25% recommended dose of nano NPK as foliar application], T5 [Soil application of 50% RDF as Traditional fertilizer + 50% recommended dose of nano NPK as foliar application], T6 [Soil application of 25% RDF as Traditional fertilizer + 75 % recommended dose of nano NPK as foliar application],T7[100% recommended dose of fertilizer as Traditional fertilizer Soil application],T8[100% recommended dose of nano N as foliar application, P&K as Soil application],T9[100% nano fertilizer as Foliar spray],T10[Absolute Control].

RESULTS AND DISCUSSION

(A)Growth attributes:

At 30 DAS highest plant height (24.28cm) was recorded in the treatment T2 followed by T3(22.05). The lowest plant height (13.21 cm) was recorded in T10 (Absolute Control). At 60 DAS highest plant height (91.62cm) was recorded in the treatment T2 followed by T5(89.37). The lowest plant height (66.81 cm) was recorded in T10 (Absolute Control). At 90 DAS highest plant height (120.21 cm) was recorded in the treatment T2followed by T5(115.89) and T3(113.91). The lowest plant height (80.62 cm) was recorded in T10 (Absolute Control).

At 30 DAS highest number of leaves per plant (14.51) was recorded in the treatment T2 followed by T5(12.66). The lowest number of leaves per plant (8.54) was recorded in T10(Absolute Control). At 60 DAS highest number of leaves per plant (42.60) was recorded in the treatment T2followed by T5(40.05). The lowest number of leaves per plant (26.29) was recorded in T10(Absolute Control). At 90 DAS highest number of leaves per plant (83.99) was recorded in the treatment T2 followed by T5(80.52). The lowest number of leaves per plant (59.75) was recorded inT10 (Absolute Control).

At 60 DAS highest number of branches per plant (2.50) was recorded in the treatment T2 followed by T5(2.25). The lowest number of branches per plant (1.08) was recorded in T10 (Absolute Control).At 90 DAS highest number of branches per plant (3.62) was recorded in the treatment T2 followed by T5(3.41). The lowest number of branches per plant (1.26) was recorded in T10(Absolute Control).

The enhancement effect of nano fertilizers on these studied characteristics may be attributed to the fact that it has a dimension ranging from 30 to 40 nm which is able to hold numerous ions because of their high surface area and slowly release them in a timely manner to cope with crop demand. Moreover, their slow release and super sorbent phosphatic and nitrogenous fertilizers [9]. The reason might also be attributed to the role of the elements nitrogen and phosphorous, which are included in the synthesis of nucleic acids DNA, RNA, and proteins and their role in increasing cell growth and division, and potassium also have an important role as it works to activate the enzymes responsible for building proteins [10].

Nofal *et al*., [9] found that plant fresh weight, leaf area, head fresh weight and head size of lettuce significantly increased by the application of nano N, P and K fertilizers. Moreover, the highest obtained values were recorded with nano nitrogen at the rate of 50 % compared to other nano treatments and NPK conventional fertilizers (control). Kanjana *et al*.,[11] has reported that nano fertilizers increased the plant height at square formation (45 DAS) and harvest stage of the crop than normal source of micronutrients and control. Also similar results were obtained in the findings of Sohair *et al*., [12] ,showed that significant increase in the sympodial branches was achieved with the application of of 50% RFD of nano NPK fertilizers. Significant increase in the height of the plant and the highest increase is has been achieved when the fertigation of the combination of nano NPK fertilizers (53.43 cm) and the traditional fertilizer NPK of (44.33 cm) compared with the comparison treatment, good potato productivity can be achieved through the adoption of fertigation combined with nano N,P and K fertilizers and good irrigation management using dripping irrigation according to the study conducted by Hayyawi and Qusay[13].

(B) Yield Attributes:

The maximum fruit length (12.75 cm) was recorded in treatment T2 followed by T5(12.45). The minimum fruit length (9.08 cm) was recorded in T10 (Absolute Control).The maximum fruit width (1.65 cm) was recorded in treatment T2 followed by T5(1.60). The minimum fruit

width (1.07 cm) was recorded in T10(Absolute Control). Similarly, the highest number of pods per plant (29.23 cm) was recorded in treatment T2followed by T5(27.22). The minimum number of pods per plant (19.66 cm) was recorded in T10(Absolute Control). The maximum average of pod weight (g) (29.23 cm) was recorded in treatment T2 followed by T5(12.31). The minimum average of pod weight (g) (19.66 cm) was recorded in T10. The maximum pod yield per plant (g) (370.39) was recorded in treatment followed by T5(335.10),The minimum pod yield per plant (g) (200.48) was recorded in T10(Absolute Control). The maximum pod yield per plot (kg) (8.89) was recorded in treatmentT2) followed by T5(8.04). The minimum pod yield per plot (kg) (4.81) was recorded in T10(Absolute Control). The maximum pod yield (q ha-1) (131.69) was recorded in treatment T2 followed by T5(119.15). The minimum pod yield (q ha-1) (71.28) was recorded in T10 (Absolute Control).

Nano fertilizers play an important role in the crop production up to 35 to 40% of the productivity. Below 50 nm size, the laws of classical physics give way to quantum effects, provoking different optical, electrical and magnetic behaviors. Nano sized active ingredients in fertilizer help to improve nutrient use efficiency and this could be due to their high specific surface area, which facilitates good absorption of the nutrients. The distribution of nano NPK element was found to be uniform and their use efficiency was 97.43 %, 98.11% and 97.03 %, respectively. Soil application nano fertilizers are synthesized so as to regulate the release of nutrients depending on the requirements of the crops. Due to nanostructured formulation of fertilizer release of nutrients into the soil happens gradually and in a controlled way which is beneficial to increase soil microbial population and enzyme activity. Foliar feeding enhances plant height, leaf area, number of leaves per plant, dry matter production, chlorophyll production, rate of the photosynthesis resulting in more production and translocation of photosynthates to different parts of the plant. Nano particles can penetrate the stomatal pores with the size less than 50 nm, hence significantly augment nutrient absorption and aid in production as compared with traditional fertilizers [14].

Kumbhar et al., [15] has observed that nitrogen application promoted photosynthetic rate, assimilates production and accumulation that ultimately boosted final seed cotton yield. Davarpanah et al., [16] found that a small amount of nano N applied via foliar fertilization improves yield and quality in pomegranate orchards established in less fertile soil. In an experiment carried out using integrated nano fertilizer Huong et al., [17] reported that the ability of the plant to build up dry matter influences the formation of active ingredients in the Polyscias fruticosa, thereby affecting the quality of the medicinal plants (roots and leaves) after harvest. Using an integrated nano fertilizer helped to improve the ability to accumulate dry matter of Polyacids fruticose, thereby increasing the value and economic benefits of the plant. In study conducted by Nofal et al,.[9] it was found that the yield and marketable yield were significantly increased gradually with the increase in nano N – P – and K rates. Moreover the highest significant increase in total and marketable yield was produced from nano nitrogen application at the rate of 50% compared to other nano treatments and control. Similar results were given by Mishra et al., [18] on an experiment carried in tomato using nano fertilizer. the interaction between nanoparticle and fertilization achieved increased concentrations of nitrogen and phosphorous elements in the fruits, therefore, this reflected positively on the increase in growth and yield, and the improvement of production and quality. From his field experimental study Jabri et al.,[19] have concluded that the interaction between nanoparticle and fertilization achieved increased concentrations of nitrogen and phosphorous elements in the fruits, therefore, this reflected positively on the increase in growth and yield, and the improvement of production and quality.

(C) Quality Attribute

T.S.S. of fruit

The maximum TSS (Brix) (2.93) was recorded in treatment T2followed by T5(2.82). The minimum TSS (0Brix) (2.14) was recorded in Absolute Control.

These findings are in close consonance with those of Nofal etal,.[9] it was found that 50 % of nano potassium treatment produced the highest significant increment of ascorbic acid, TSS and head total sugars content. The increase in ascorbic acid TSS and head sugar content may be attributed to The role of potassium in photosynthesis is very important due to the activation of enzymes by K and its involvement in adenosine triphosphate (ATP) production is probably more important in regulating the rate of photosynthesis. As it is known that, ascorbic acid synthesized from sugars supplied through photosynthesis in plants Lee and Kader et al.,[20]. Which was also supported by[9]. Davarpanah et al.,[16] on a study on foliar nano nitrogen have reported that increases in TSS in juice were found with the treatments nN2(0.50) and U1(4.60). This was also supported by the findings of Sarker and Rahimet al.,[20] Singh et al.,[21].

Table 1 Effect of Nano Fertilizer on growth traits of Okra:

Treatment No.	Plant height (cm)			Number of leaves per plant			Number of branches per plant	
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS
T1	18.99	81.66	103.55	11.08	36.29	73.85	1.95	2.12
T2	24.28	91.62	120.21	14.51	42.60	83.99	2.50	3.62
T3	22.05	86.28	113.91	12.36	39.49	78.99	2.18	3.34
T4	17.74	80.19	100.88	10.65	35.34	70.22	1.74	2.64
T5	20.60	89.37	115.89	12.66	40.05	80.52	2.25	3.41
T6	20.16	83.65	109.66	11.75	37.71	76.76	2.08	2.89
T7	16.35	77.77	97.46	10.55	35.54	67.18	1.59	1.95
T8	16.28	74.12	92.55	10.47	31.45	68.55	1.41	1.75
T9	16.22	72.66	89.52	10.00	30.75	63.18	1.43	1.57
T10	13.21	66.81	80.62	8.54	26.29	59.75	1.08	1.26
F-Test	S	S	S	S	S	S	S	S
C.D. at 0.5	1.81	2.86	3.01	1.05	1.76	7.27	0.21	0.31
S.Ed.	0.86	1.36	1.43	0.50	0.84	3.46	0.10	0.15
CV	5.66	2.07	1.71	5.43	2.88	5.86	6.62	7.46

Table 2: Effect of Nano fertilizer on yield and quality traits of Okra :

Treatment No.	Yield traits								Quality trait
	Days to first harvesting	Pod length (cm)	Pod width (cm)	Number of pods per plant	Average of pod weight (g)	Pod yield per plant (g)	Pod yield per plot (kg)	Pod yield (q ha-1)	TSS
T1	55.59	11.65	1.41	23.55	12.08	284.47	6.83	101.14	2.66
T2	46.97	12.75	1.65	29.23	12.67	370.39	8.89	131.69	2.93
T3	50.63	12.31	1.57	26.51	12.23	324.36	7.78	115.33	2.79
T4	57.65	11.49	1.33	21.68	11.86	257.14	6.17	91.43	2.51
T5	48.91	12.45	1.60	27.22	12.31	335.10	8.04	119.15	2.82
T6	53.52	12.24	1.48	24.77	12.18	301.56	7.24	107.22	2.70
T7	59.55	11.27	1.24	21.61	11.63	251.49	6.04	89.42	2.39
T8	61.28	10.66	1.28	20.91	11.48	240.12	5.76	85.37	2.34
T9	59.92	10.19	1.24	20.36	10.70	217.82	5.23	77.45	2.27
T10	61.75	9.08	1.07	19.66	10.20	200.48	4.81	71.28	2.14
F-Test	S	S	S	S	S	S	S	S	S
C.D. at 0.5	2.68	2.68	0.16	2.07	0.30	27.02	0.65	9.61	0.09
S.Ed.	1.28	1.28	0.08	0.99	0.14	12.86	0.31	4.57	0.18
CV	2.81	2.81	6.89	5.13	1.47	5.66	5.66	5.66	4.09

CONCLUSION

Based on the result of experiment, it may be concluded that the treatment T2 (Soil application of 50% RDF as Traditional fertilizer + 50 % recommended dose of nano N as foliar application , P&K as soil application) was recorded the best among in all combination of Traditional fertilizer NPK and nano NPK in term of growth, yield and quality parameters .

REFERENCES

[1] Tripati K K, Warrier R , Govilla O.P ,Vibha A. Biology of abelmoschus esculentus l. (okra), Series of crop specific biology document, Department of biotechnology, Ministry of science and technology GOI.

[2] Jagdish.Singh., T. K .Behera ., A. K. Singh.(2021) Vegetables for better nutrition and safe environment, *Indian Horticulture (sept-oct 2021).*

[3]Rashid, M.M. 1999. Sabji Biggan (Vegetables Science). 2nd edition, *Rashid Publishing House, Dhaka.*

[4]R. Meher., J. Mandal., S. Mohanta ,(2016) Performance of okra [Abelmoschus esculentus (L.) Moench] cultivars under Red and Laterite Zone of West Bengal.

[5] D. Vasundhara and Vandna Chhabra (2020) Use of nano-fertilizers in crops-A review *International Journal of Scientific & Engineering Research Volume* 11 ISSN 2229-5518.

[6] Drostkar , E. ; Talebi, R. and Kanouni, H. (2016). Foliar application of Fe, Zn and NPK nano-fertilizers on seed yield and morphological traits in chickpea under rainfed condition. *J. of Res. in Ecology. 4(2): 221-228.*

[7] A. Ditta and M. Arshad.,(2016) "Applications and perspectives of using nanomaterials for sustainable plant nutrition," Nanotechnology Reviews, vol. 5, no. 2, pp. 209–229.

[8] Pallerla. Saisupriya and Pidigam .Saidaiah.,(2021) Application of Nanotechnology in Vegetable Crops. *Just agriculture multi-disciplinary e-newsletter.*

[9] A. S. Nofal, A. E. Ashmawi, A. A. Mohammed, M. T. El- Abd, and A. A. Helaly(2021) Effect of soil application of nano NPK fertilizers on growth, productivity and quality of Lettuce (Lactuca sativa) Al-Azhar Journal of Agricultural Research V. (46) No. (1) June (2021) 91100.

[10] Aman H. J. AL-Kaby1 Talib M. M. AL-Jarah2 and Jameel H.Haji (2021) The response of okra plants Abelmoschus esculentus (L) Moenth. Cultivated in greenhouses for foliar

spraying with nano fertilizer NPK. *International Scintific Agrticultural Conference IOP Conf. Series: Earth and Environmental Science* 735 (2021) 012044 IOP Publishing doi:10.1088/1755-1315/735/1/012044.

[11] D. Kanjana(2020) Evaluation of Foliar Application of Different Types of Nanofertilizers on Growth, Yield and Quality Parameters and Nutrient Concentration of Cotton under Irrigated Condition. *International Journal of Current Microbiology and Applied Sciences* ISSN: 2319-7706 Volume 9 Number 7 (2020).

[12] Sohair. EED ., Abdall ., Amany ., Hossain and Houda .,(2018). Evaluation of Nitrogen, Phosphorus and Potassium Nano-Fertilizers on Yield, Yield Components and Fiber Properties of Egyptian Cotton (Gossypium Barbadense L.) *Journal of Plant Sciences and Crop Protection*. ISSN: 2639-3336.

[13] Hayyawi W.A.Al- juthery,Qusay.M.N.Al-Shami (2019) The Effect of Fertigation with Nano NPK Fertilizers on Some Parameters of Growth and yield of potato (Solanum tuberosum L.). *QJAS Al-Qadisiyah Journal For Agriculture Sciences* ISSN: 2618-1479 Volume 9, No.2 ,(2019), PP 225-232.

[14] Akhlesh C , Arti C and Sarita S (2020) Nano Fertilizers Used for Field Crop in Chhindwara District of Madhya Pradesh. *Ind. J. Pure App. Biosci*. (2020) 8(5), 462-465 ISSN: 2582 – 2845.

[15] A.M. Kumbhar, U.A. Buriro, S. Junejo, F.C. Oad, G.H. Jamro, B.A. Kumbhar And S.A. Kumbhar. Impact of different nitrogen levels on cotton growth, yield and n-uptake planted in legume rotation. *Pak. J. Bot*., 40(2): 767-778, 2008.

[16] S Davarpanah, Ali Tehranifar1 , and Gholamhossein Davarynejad(2017),. Effects of Foliar Nano-nitrogen and Urea Fertilizers on the Physical and Chemical Properties of Pomegranate (Punica granatum cv. Ardestani) Fruit. *HORTSCIENCE VOL*. 52(2) FEBRUARY 2017 52(2):288–294. 2017. doi: 10.21273/HORTSCI11248-16.

[17] Thi Thu Huong Le , 1,2 Thi Thu Trang Mai , 1 Ke Son Phan , 1 Thi Minh Nguyen,3 Thi Lan Anh Tran,1 Thi Nham Dong,1 Huu Chung Tran,4 Thi Thanh Hang Ngo,4 Phuong Ha Hoang,3 and Phuong Thu Ha,.(2022) Novel Integrated Nanofertilizers for Improving the Growth of Polyscias fruticosa and Asparagus officinalis. *Hindawi Journal*

of Nanomaterials Volume 2022, Article ID 5791922, 10 pages https://doi.org/10.1155/2022/5791922.

[18] Babita Mishra, G.S. Sahu , L.K. Mohanty , B.C. Swain and S. Hati Effect of Nano Fertilizers on Growth, Yield and Economics of Tomato Variety Arka Rakshak. *Ind. J. Pure App. Biosci. (*2020) 8(6), 200-204.

[19] Abdul Rahman A.B. Al Jabri, Raheem A.H. Jassim and Abdullah Kareem Jabar.,(2020) The effect of nano nitrogen and bio-fertilizer types on npk concentration in soil and okra plant. Plant Archives Vol. 20, Supplement 2, 2020 pp. 4031-4037 e-ISSN:2581-6063 (online), ISSN:0972-5210.

[20] Sarker, C.B. and M.A. Rahim., 2013. Yield and quality of mango (Mangifera indica l.) as influenced by foliar application of potassium nitrate and urea. Bangladesh J. Agr. Res. 38:145–154.

[21] Singh, N.P., C.S. Malhi, and R.C. Sharma., 2005. Effect of foliar feeding of N, P and K on vegetative and fruiting characteristics of mango cv. Dashehari. International Conference on Mango and Date Palm; Culture and Export. p. 27–31.